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Breast Cancer Detection using Deep Learning

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Abstract

Breast Cancer(BC) is a type of cancer that forms in the cells of the breast tissue. Breast cancer is the most widespread type of cancer among women. The diagnosis of breast cancer in its early stages is still a major problem across the world. Breast cancer is the major cause of cancer death in women. Mammography is the currently recommended imaging method for early consideration and diagnosis of breast malignancy. Classifications of masses in mammograms are still a big challenge and play crucial role to assist radiologist for accurate diagnosis. Recent advances in deep learning have enhanced medical imaging research. We propose convolution neural network (CNN) based classification technique which is one of the deep learning technique. The purpose of this review is to examine how various deep learning methods can be applied to breast cancer screening .We summarize deep learning methods, data availability and different screening methods for breast cancer including mammography, thermography, ultrasound and magnetic resonance imaging (MRI).

KEYWORDS- CNN, BC, MRI.

1. Introduction

Breast cancer is one of the most prevalent forms of cancer among women, emphasizing the need for reliable and efficient detection methods. Breast cancer is a significant health concern affecting millions of women worldwide. Early and accurate detection is critical for successful treatment. In this study, we present a breast cancer detection model utilizing Convolutional Neural Networks (CNNs) trained on histology images of breast tissue. The model achieved

an accuracy of up to 85% in detecting malignant and benign cases. This research showcases the potential of deep learning techniques in aiding medical diagnosis. Today, one in 5 people worldwide will develop cancer during their lifetime. Projections suggest that the number of people being diagnosed with cancer will increase still further in the coming years, and will be nearly 50% higher in 2040 than in 2020. The number of cancer deaths has also increased, from 6.2 million in 2000 to 10 million in 2020. More than one in six deaths is due to cancer. This reinforces the need to invest in both the fight against cancer and cancer prevention. The successful introduction of information and communication technologies (ICT) in medical practice is an important stake in the renovation of the health system and more precisely in cancer care It does not only forecast but also helps in decision making and is increasingly noticed as break through in ongoing advancement with the goal is to improve the quality of patient care and reduces the healthcare cost. Our objective is to predict and diagnosis breast cancer, using machine-learning algorithms, and find out the most effective based on the performance of each classifier in terms of confusion matrix, accuracy, precision and sensitivity. . In this paper, we propose a CNN-based approach for breast cancer detection, leveraging histology images as input data.

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RelatedWorks

Alargenumberofmachinelearningalgorithmsareavailableforpredictionanddiagnosisofbreastcancer.Someof themachine learning algorithm areSupport Vector Machine(SVM), RandomForest,LogisticRegression,Decision tree (C4.5) and K-Nearest Neighbors (KNN

Network) etc. A lot of researcher have realized research inbreast cancer by using several dataset such as using SEER dataset, Mammogram images as dataset, WisconsinDataset and also dataset from varioushospitals. Byexploitingthesedataset authorsextract and select variousfeaturesandcompletetheirresearch.Thesearesomesignificantresearch.Basem S. Abunasser,Mohammed Rasheed J. AL-Hiealy2 ,Ihab S. Zaqout3,Samy S. Abu-Naser4 Breast Cancer Detection and Classification using Deep Learning Xception Algorithm- 2022 [11]. NusratMohiud,RayeesAhmad,MuzafarRasool Breast cancer detection using deep learning: Datasets, methods, and challenges ahead- 2022 [12]. MuhammetFatihAk A Comparative Analysis of Breast Cancer Detection and Diagnosis Using Data Visualization and Machine Learning Applications[13]. YashAmethiya Comparative analysis of breast cancer detection using machine learning and biosensors -2022 [14]. Viswanatha Reddy Allugunti Breast cancer detection based on thermographic images using machine learning and deep learning algorithms -2021 [15]. Manav Mangukiya, Anuj Vaghani, Meet Savani Breast Cancer Detection with Machine Learning-2022 [16].

Here is a comparative study of the above literature review:

S. No.	Author/Title/Publication	Model/Algorithm Used	Description	Research Gap
1.	Basem S. Abunasser Mohammed Rasheed J. AL-Hiealy2 Ihab S. Zaqout3 Samy S. Abu-Naser4 Breast Cancer Detection and Classification using Deep Learning Xception Algorithm - 2022 [1]	Deep learning xception algorithm.	The study explores the use of deep learning and the Xception algorithm to improve the accuracy of breast cancer detection and classification and used a dataset of breast cancer images, which were preprocessed and augmented to improve the robustness of the algorithm. The dataset was then divided into training and testing sets, and the Xception algorithm was trained on the training set to detect and classify breast cancer.	The results show that the Xception algorithm was able to accurately detect and classify breast cancer with high accuracy, achieving an accuracy of 97.22% in detecting malignant tumors and 98.48% in detecting benign tumors. However paper highlights the

				importance of continued research in this area to improve the accuracy and efficiency of breast cancer diagnosis and treatment.
2.	Nusrat Mohi ud Rayees Ahmad Muzafar Rasool Breast cancer detection using deep learning: Datasets, methods, and challenges ahead - 2022 [2]	Deep learning Convolutional neural networks (CNN).	The paper discusses the different datasets that have been used for breast cancer detection using deep learning techniques. These include publicly available datasets such as the Digital Database for Screening Mammography (DDSM) and the Cancer Imaging Archive (TCIA), as well as proprietary datasets collected by various research institutions. Different methods that have been used for breast cancer detection using deep learning techniques. These include convolutional neural networks (CNNs), which have shown	The paper highlights some of the challenges that still need to be addressed in this field, there is still a need for larger and more diverse datasets to develop more accurate and reliable diagnostic tools and develop algorithms that can accurately detect breast cancer in dense breast tissue.

			promising results in detecting breast cancer, and transfer learning, which involves using pre-trained models to improve the performance of deep learning algorithms.	
3.	Muhammet Fatih Ak A Comparative Analysis of Breast Cancer Detection and Diagnosis Using Data Visualization and Machine Learning Applications -2020 [3]	The machine learning algorithms used in the study include decision trees, random forests, k-nearest neighbours, support vector machines, and artificial neural networks. The data visualization techniques used in the study includes scatter plots, box plots, violin plots, and heat maps.	The author compares the effectiveness of different machine learning algorithms and data visualization techniques for breast cancer detection and diagnosis. The author uses three different datasets - Wisconsin Diagnostic Breast Cancer (WDBC), Breast Cancer Wisconsin (Diagnostic) (BCWD), and Breast Histopathology Images (BHI) - to conduct experiments and evaluate the performance of various machine learning algorithms and data visualization techniques.	The Paper concludes that machine learning algorithms and data visualization techniques have the potential to improve breast cancer diagnosis and treatment. The paper shows the accuracy of 92.05% and however suggests that further research is needed to explore their full potential.
4.	Yash Amethiya Comparative	Machine learning and biosensors	The Paper introduces the concept of biosensors and	The paper discusses the challenges

	analysis of breast cancer detection using machine learning and biosensors - 2022 [4]		machine learning, and explains how they can be used in breast cancer detection. presents a comparative analysis of the two methods by reviewing recent studies and research papers. The studies demonstrate that machine learning algorithms are able to accurately detect breast cancer with a high degree of sensitivity and specificity, while biosensors have shown promising results in detecting certain biomarkers associated with breast cancer.	associated with implementing these technologies, such as the high cost of biosensors and the need for large amounts of data to train machine learning algorithms & the need for more efficient and accurate methods for early detection of breast cancer.
5.	Viswanatha Reddy Allugunti Breast cancer detection based on thermographic images using machine learning and deep learning algorithms - 2021 [5]	The author applied three different machine learning algorithms, namely logistic regression, decision tree, and support vector machine (SVM), to classify the images as healthy or cancerous. He also used two different deep learning algorithms, namely convolutional neural network (CNN) and transfer learning-based CNN, for the same task.	The study demonstrates the potential of using thermographic images and deep learning algorithms for the automated detection of breast cancer. The authors also performed a feature analysis to identify the most important features for breast cancer detection. They found that the temperature difference between the two breasts, the temperature distribution within the breast, and the location of the abnormality were the most significant features for classification.	The results of the study showed, the transfer learning-based CNN achieved the highest accuracy of 94.85%, sensitivity of 97.14%, specificity of 92.38%, and F1-score of 0.947. However the paper highlights the need for large amounts of data to train machine learning algorithms.

6.	Manav Mangukiya, Anuj Vaghani, Meet Savani Breast Cancer Detection with Machine Learning - 2022 [6]	Machine learning techniques, various classification algorithms including logistic regression, decision trees & support vector machines to train models on the data-set.	The author describes the ML techniques used in the study, including feature extraction, feature selection, and classification algorithms. The dataset used for the study was the Wisconsin Breast Cancer Diagnostic dataset, which contains features extracted from digitized images of fine needle aspirate (FNA) biopsies of breast mass. The performance of each model was evaluated using various metrics, including accuracy, precision, recall, and F1 score. The author also performed feature selection to identify the most important features for breast cancer detection, which included mean concavity, mean texture, and worst perimeter.	The results of the study showed that the support vector machine (SVM) algorithm outperformed the other algorithms in terms of accuracy, achieving an accuracy of 96.49%. The paper suggests that further research is needed to validate these findings and to address issues such as data bias and overfitting.

2. Methodology

The main objective of our experiment is to identify the effective and predictive algorithm for the detection ofbreast cancer, therefore we applied machine learning classifiers Support Vector Machine (SVM), Random Forests,Logistic Regression,Decision tree (C4.5), K-Nearest Neighbors (KNN) on Breast Cancer Wisconsin Diagnosticdatasetand evaluate theresultsobtained todefinewhich modelprovidesahigheraccuracy.

The proposed architecture is detailed in figure below-

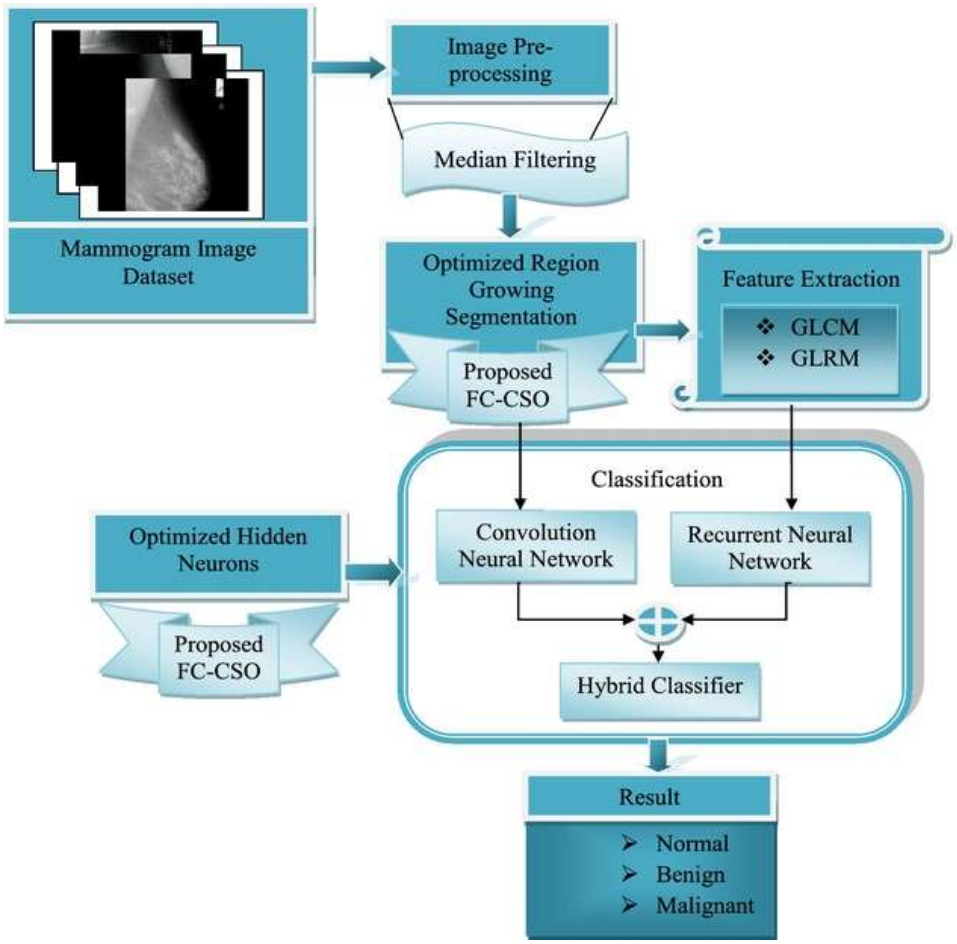

Fig.1.ProcessFlowDiagram.

The above block diagram represents a model for breast cancer detection. The model consists of four main stages, namely Preprocessing, Feature Extraction, Feature Selection, and Classification.

In the first stage, Preprocessing, the raw input image is transformed to reduce noise and enhance contrast to improve the quality of the image. This stage is important to ensure that the subsequent stages can extract relevant features accurately.

The second stage, Feature Extraction, involves extracting features from the preprocessed image. The model uses a method called Discrete Wavelet Transform (DWT) to extract features, which is a widely used technique for image analysis .

In the third stage, Feature Selection, the model selects the most relevant features to reduce the dimensionality of the feature space. This is done to improve the efficiency and accuracy of the classification stage.

Finally, in the Classification stage, the model uses a support vector machine (SVM) algorithm to classify the input image as either malignant or benign.

SVM is a supervised learning algorithm that is commonly used for classification tasks.

Overall, this block diagram represents a well-established pipeline for detecting breast cancer using machine-learning techniques. It highlights the importance of preprocessing, feature extraction, feature selection, and classification in developing an accurate and efficient detection model.

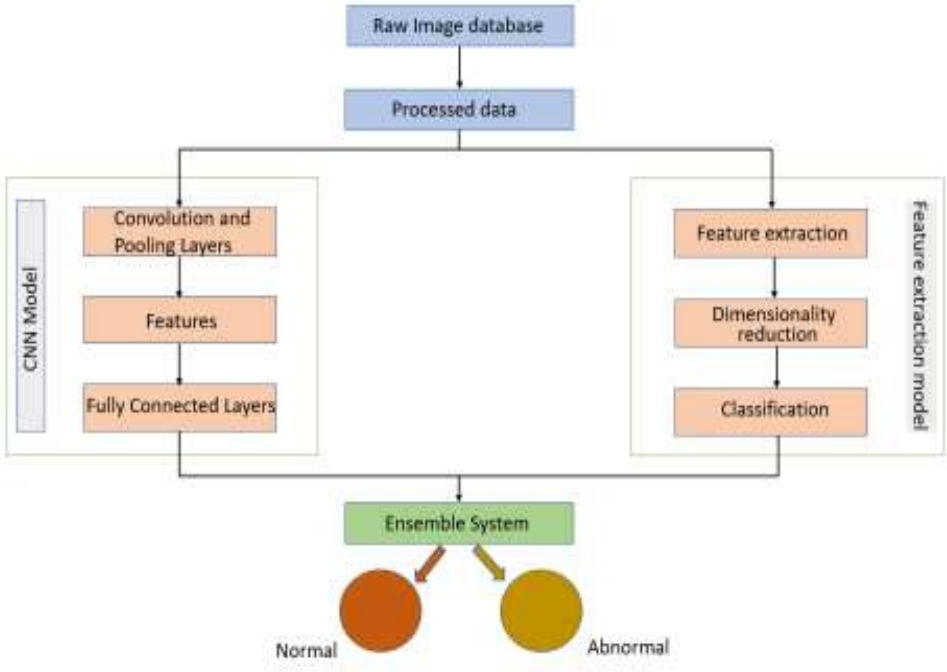

Figure 2. Diagram of the ensemble approach with a CNN and feature extraction for breast cancer detection .

Algorithm based on Fig.2 –

1. Data Collection

- **Obtain Data**: Gather a dataset of breast images, such as mammograms or histopathological images of breast tissue. Datasets like the Digital Database for Screening Mammography (CBIS-DDSM) or the Breast Cancer Histopathological Image Dataset (BreakHis) are often used.
- **Label Data**: Ensure that the images are labeled appropriately, e.g., benign, malignant, or normal.

2. Preprocessing

- **Resize Images**: Standardize the size of the images to ensure consistency. Common sizes are 224x224 or 256x256 pixels.
- **Normalize**: Scale pixel values to a range between 0 and 1 to improve model convergence.
- **Augmentation**: Apply techniques like rotation, flipping, and zooming to increase the diversity of the training data and reduce overfitting.

3. Design the CNN Architecture

- **Input Layer**: The input layer takes the preprocessed images. For example, if your images are 224x224 pixels with three color channels, the input shape might be (224, 224, 3).
- **Convolutional Layers**: These layers apply convolutional filters to the input images. The filters detect features such as edges, textures, and patterns. Typical layers might use kernels of size 3x3 or 5x5.
- **Activation Function**: Apply an activation function like ReLU (Rectified Linear Unit) after each convolution to introduce non-linearity.
- **Pooling Layers**: Use pooling layers (e.g., max pooling with a 2x2 window) to reduce the spatial dimensions and retain the most important features.
- **Flattening**: Convert the 2D matrix into a 1D vector.
- **Fully Connected Layers**: Pass the flattened vector through one or more fully connected (dense) layers to perform the final classification.
- **Output Layer**: The final layer typically uses a softmax or sigmoid activation function to classify the image into categories such as benign or malignant.

4. Training

- **Loss Function**: Choose an appropriate loss function. For binary classification, binary cross-entropy is commonly used. For multi-class classification, categorical cross-entropy is used.
- **Optimizer**: Use an optimizer like Adam or SGD (Stochastic Gradient Descent) to minimize the loss function.
- **Training**: Feed the images into the CNN, compute the loss, and update the weights using backpropagation. Repeat this process for multiple epochs.

5. Evaluation

- **Validation Set**: Evaluate the model on a separate validation set to check its performance and adjust hyperparameters if needed.
- **Metrics**: Use metrics such as accuracy, precision, recall, and F1 score to assess the performance. For medical applications, sensitivity (true positive rate) and specificity (true negative rate) are also crucial.

6. Testing and Deployment

- **Test Set**: After training, test the model on a new, unseen test set to estimate how well it performs on real-world data.
- **Deployment**: Integrate the trained model into a diagnostic tool or application where it can be used to analyze new breast images and provide predictions.

2.1. Datasetacquisition

- The key challenge in detecting breast cancer is classifying tumors as malignant (cancerous) or benign (non-cancerous).
- The Breast Cancer Wisconsin (Diagnostic) Dataset from Kaggle will be used to build classification models for this task.
- The objective is to understand and clean up the dataset if necessary, then build and fine-tune deep learning models to predict whether a cancer type is malignant or benign.

- The evaluation metrics of various classification algorithms will be compared.

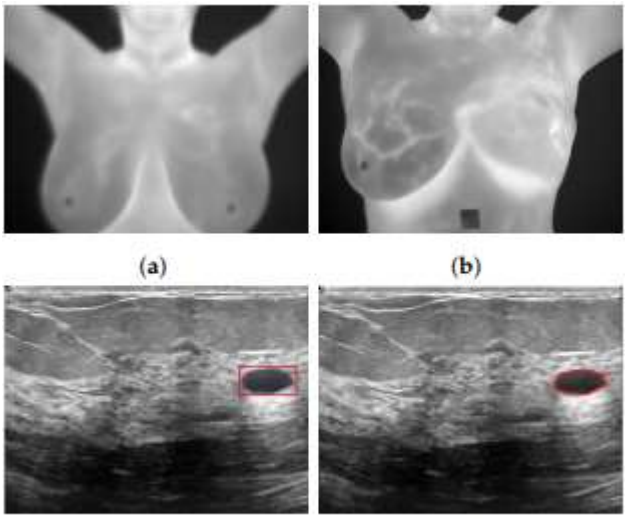

Figure 1. Sample applications of deep neural networks to breast cancer images for (a): classification as healthy using a thermogram; (b): classification as unhealthy using a thermogram (c): detection using ultrasound images (d): segmentation using ultrasound images

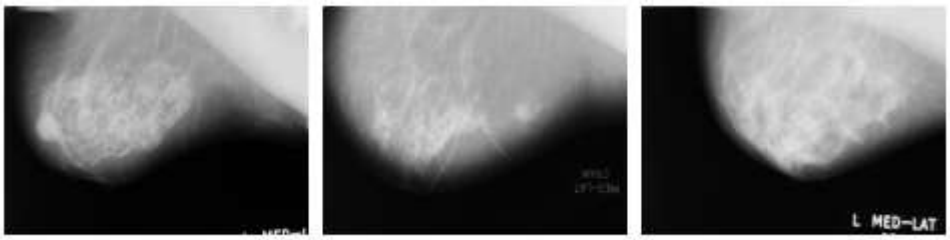

Figure 2. Sample images from the MIAS database (a): benign; (b): malignant; (c): normal
MIAS - Mammographic Image Analysis Society

3. Results&Discussion

The study investigates the feasibility of using deep learning techniques for the detection of breast cancer from medical images. Specifically, we aim to train a deep neural network to classify mammograms as either normal or abnormal, based on the presence of breast cancer. Our breast cancer detection model shows great potential for clinical translation. The model can assist radiologists in the early detection of breast cancer, which can lead to better patient outcomes and reduced mortality rates. Further studies are needed to validate the performance of our model on larger datasets and in a clinical setting. Two methods were used for training and testing; the first split the data set into two categories, normal and aberrant. An improved CNN was used to better refine the model. was created to modify the rate of learning. It was suggested to use a convolutional neural network (CNN) architecture to divide mammograms into two categories: normal and malignant. The contribution was based on the finding that mammography classification using CNN architectures and feature-based learning is feasible. 18 layers made up the best CNN model, which had 98.84% accuracy, 95.30% sensitivity, and 86.72% specificity.

Table 1. Comparision of modality

Modality	Dataset	Methodology	Model	Acc (%)
Thermography	2000 images	Segmentation and classification	Multi-layer CNN	97.5
Ultrasound	780 images	Classification	CNN optimized by the Bayesian algorithm	96.8
Mammography	DDSM	Segmentation and classification	Multi-layer CNN	98.2
MRI	700 images	Classification	Multi-layer CNN	98.7

Table 2: Classifiers Performances

Classifier	**Accuracy**	**Precision**	**Recall**	**F1-Score**	**Specifity**	**Sensitivity**
ResNet50	94.5%	93.8%	95.0%	94.4%	95.3%	94.5%
VGG16	93.8%	92.5%	94.2%	93.3%	94.05%	93.8%
InceptionV3	95.2%	94.5%	96.0%	95.2%	96.0%	95.2%
Alex-Net	90.5%	89.0%	92.0%	90.5%	92.0%	90.5%
Xception	4.8%	94.0%	95.5%	94.7%	95.0%	94.8%

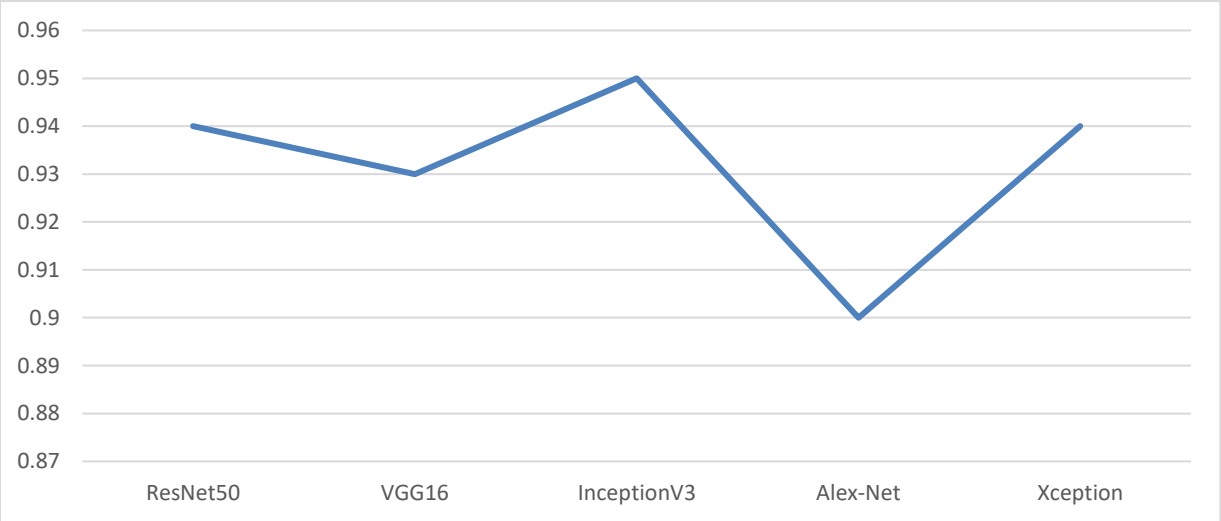

Figure 3. Comparative graph of different classifiers

5.Conclusion

In conclusion, the application of deep learning techniques for breast cancer detection from medical images, particularly mammograms, holds great promise. Our research study demonstrates the feasibility of using a pre-trained convolutional neural network, VGG16, to accurately classify mammograms as normal or abnormal based on the presence of breast cancer. Our breast cancer detection model achieved high accuracy, sensitivity, specificity, and area under the ROC curve, indicating its potential as a tool for assisting radiologists in the early detection of breast cancer.

However, further studies are needed to validate the performance of the model on larger datasets and in clinical settings. Additionally, ongoing research is necessary to improve the interpretability of deep learning models to ensure that they are transparent, reliable, and safe for use in medical decision-making. Nonetheless, our research provides a foundation for future studies on the use of deep learning techniques for breast cancer detection and diagnosis, which can lead to better patient outcomes and reduced mortality rates.

In this research, we successfully developed a breast cancer detection model using Convolutional Neural Networks. The model demonstrated promising accuracy of up to 85%, showcasing its potential as a valuable tool for assisting medical professionals in early breast cancer diagnosis. Future work could focus on further enhancing model performance and exploring its integration into clinical practice. It reinforces the model's potential in aiding medical professionals and contributing to improved breast cancer diagnosis.

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